AS Unit 1: Basic Biochemistry and Cell Organisation

Name:	Date:

Topic 1.5 Nucleic Acids and their functions – Page 3

I. DNA Replication

		Completed
1.	Go through PowerPoint	
2.	Read notes p2 and then watch the animation on Meselson and Stahl's experiments	
3.	Complete the questions on p3 and p5.	
4.	Optional reading to consolidate understanding on p8-13	
5.	Complete the practice questions p14-17	

Getting it straight

Students often mix up the topics covered in this unit. It is important that you start by understanding the processes that are being covered. The main 2 processes are DNA replication and protein synthesis (divided into transcription and translation).

Imagine 2 folders on your desktop. One is labeled 'how to make more DNA' and the other is labeled 'what DNA is used for'. Inside the first folder are the instructions for DNA replication and inside the second folder are 2 other folders labeled transcription and translation and together these contain the instructions for protein synthesis.

How to make more DNA

What DNA is used for

How to Make More DNA – DNA Replication

DNA has two main functions:

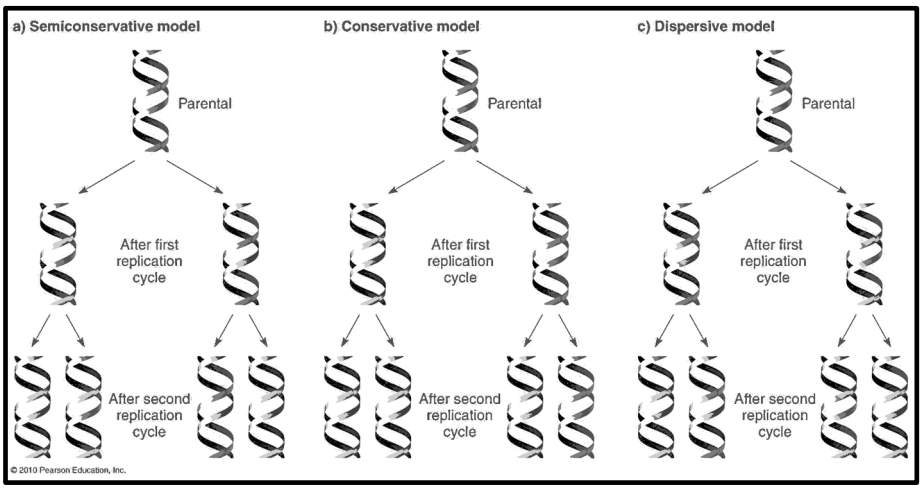
- Replication in dividing cells
- Carrying the information for protein synthesis in all cells.

DNA replication allows accurate copying of the DNA for cell division. A major requirement of any genetic material is that it should be able to replicate so that its information can be passed on from cell to cell as an organism develops and from one generation to the next. It is also vital that during replication, identical copies of DNA are made so that the information is passed on without mistakes (mutations).

DNA replication takes during **interphase** of the cell cycle; so that by the time nuclear division starts (mitosis) identical copies of each DNA molecule are already present for distribution into daughter cells.

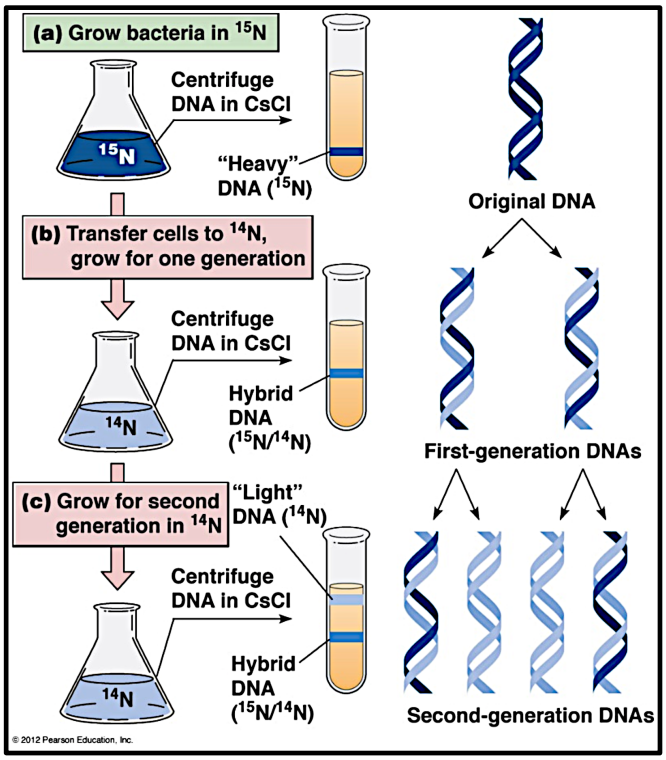
Working out the Mechanism for DNA Replication

When scientists were working out how DNA replication occurred there were three proposed models:



Meselson and Stahl designed an experiment, which built upon Watson and Crick's model and helped scientists understand exactly how DNA replicated and which of the three models was the correct one.

Watch the animation on the wikispace: Meselson and Stahl look at the diagram below and then answer the questions below:



Using the diagram and information from the animation explain how these results help to prove that it is the 'semi-conservative mechanisms' for DNA replication that should be accepted:

Semi-conservative mechanism

This model suggests that the DNA double helix gradually 'unzips' to expose bases of each strand. New nucleotides align themselves in a complimentary fashion against the bases of each parental strand. These nucleotides are joined by an enzyme **DNA polymerase** to make new polynucleotides. Therefore in the two new double helices, one strand is the original parent strand, whilst the other is newly made; i.e. only half the parental molecule is conserved in each daughter molecule.

The ability to form a new strand that is identical to the original parent strand depends upon complimentary base pairing.

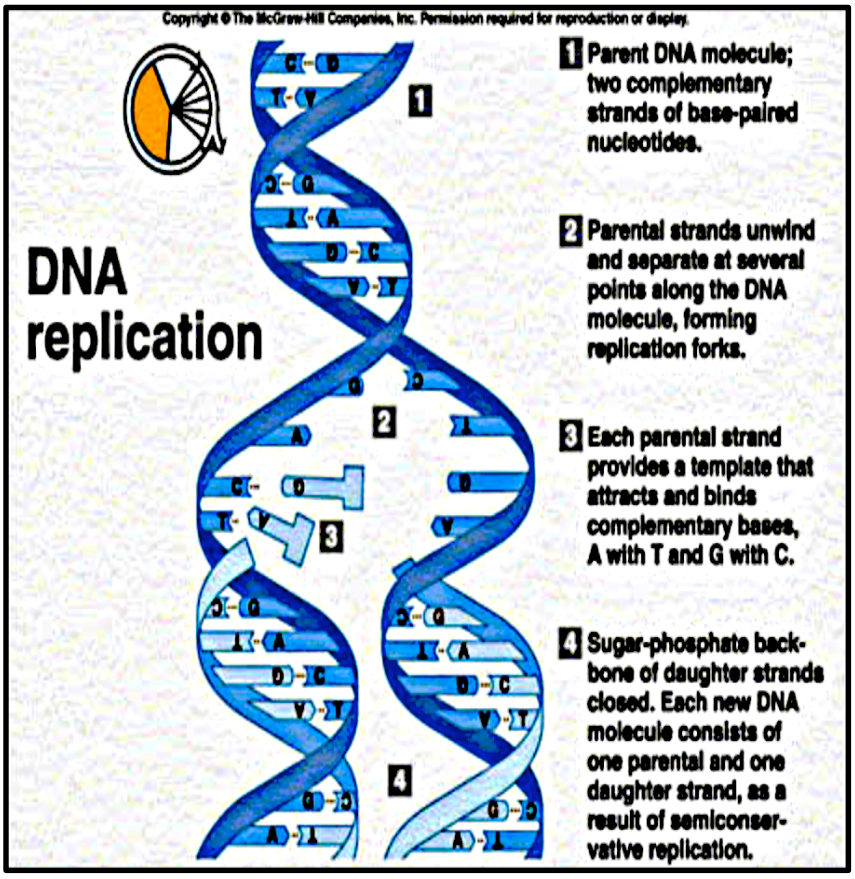
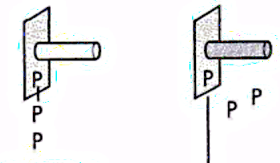


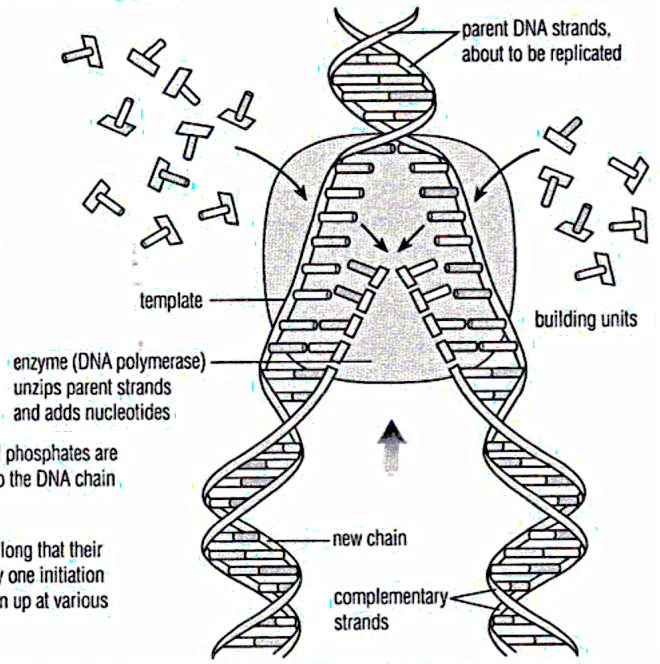
Figure 9.17 Replication of DNA: how it happens

the nucleotides for building the new DNA strands are delivered as:
- ▶ adenosine triphosphate (ATP)
- ▶ guanosine triphosphate (GTP)
- ▶ thymidine triphosphate (TTP)
- ▶ cytidine triphosphate (CTP)



deoxyribose + phosphate

at the replication site the two terminal phosphates are removed as the nucleotide is added to the DNA chain



DNA molecules in eukaryotes are so long that their length cannot be replicated from only one initiation point; instead, replication points open up at various sites along the chromosome

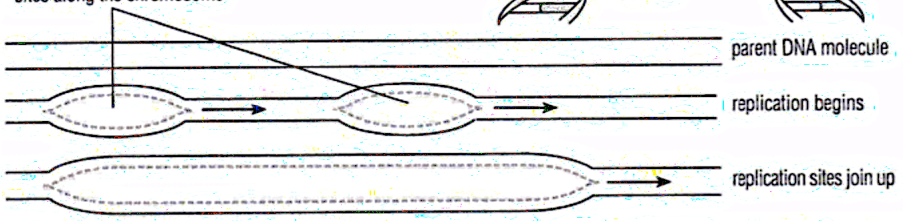
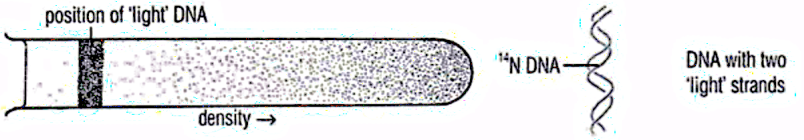


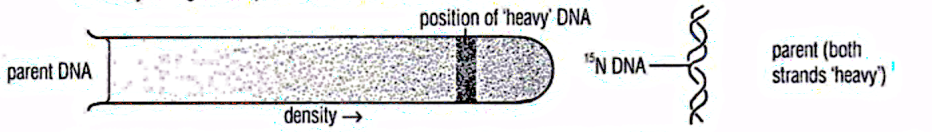
Figure 9.18 The Meselson–Stahl experiment

Stock of the bacterium *Escherichia coli* was grown in a nutrient medium in which the nitrogen is the ordinary (light) isotope, ^{14}N.

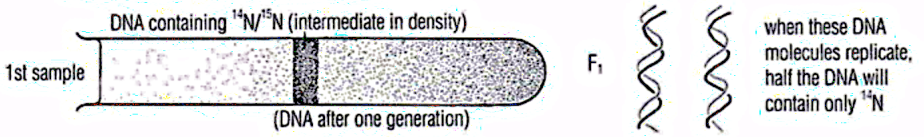
When DNA is extracted from these cells and centrifuged on a salt density gradient, the DNA separates out at the point at which its density equals that of the salt solution.



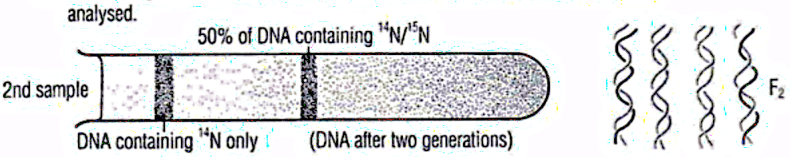
Cultures of these cells were grown for many generations in a medium containing the 'heavy' nitrogen isotope, ^{15}N; all the DNA became labelled with ^{15}N.



The labelled cells were transferred back to a culture medium containing the 'light' nitrogen isotope (^{14}N), and allowed to grow.



After each generation of cells, samples were removed and the DNA extracted and analysed.



The results can be explained if DNA replicates semi-conservatively (i.e. each strand of an existing double helix serves as a template for the synthesis of a new strand).

39 DNA replication

In an experiment to find out how DNA is replicated, Meselson and Stahl cultured *Escherichia coli* bacteria for many generations in a medium in which the only source of nitrogen was the heavy isotope ^{15}N. The DNA in the offspring of these bacteria was denser than usual because it contained ^{15}N instead of the normal isotope ^{14}N.

1 **a** Name the monomer of which DNA is made.

.....

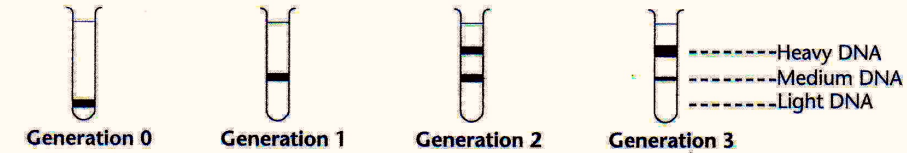
b Draw a diagram to show how the components of this monomer are arranged relative to each other.

2 **a** In which part of the DNA monomer unit will the ^{15}N be found?

.....

b Given that 15% of the bases in a piece of DNA are thymine, calculate the percentage of the bases that are guanine. Show your working.

3 The bacteria containing ^{15}N were transferred to a medium containing only ^{14}N. Samples of bacteria were taken after each generation. The DNA in each sample was extracted and centrifuged. The DNA formed bands in the tube, as shown here. (The widths of the bands indicate the proportions of the different types of DNA molecule.)



Generation 0 Grown in ^{15}N medium for many generations

Generation 1 Grown in ^{14}N medium for one generation

Generation 2 Grown in ^{14}N medium for two generations

Generation 3 Grown in ^{14}N medium for three generations

a Draw a diagram to explain how a molecule of DNA in generation 0 replicates to produce the pattern of bands found in the test tubes for generations 1 and 2. Use one colour to represent DNA strands labelled with ^{15}N and another colour to represent strands labelled with ^{14}N.

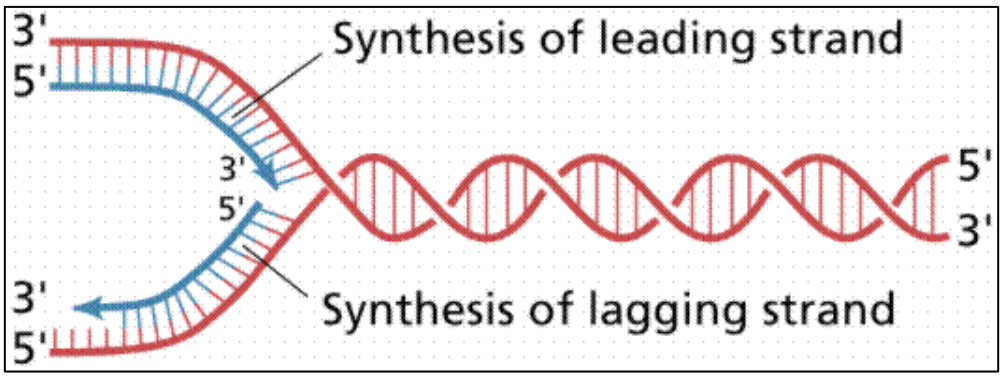
b Explain how centrifugation separates the different kinds of DNA in this experiment.

.....

.....

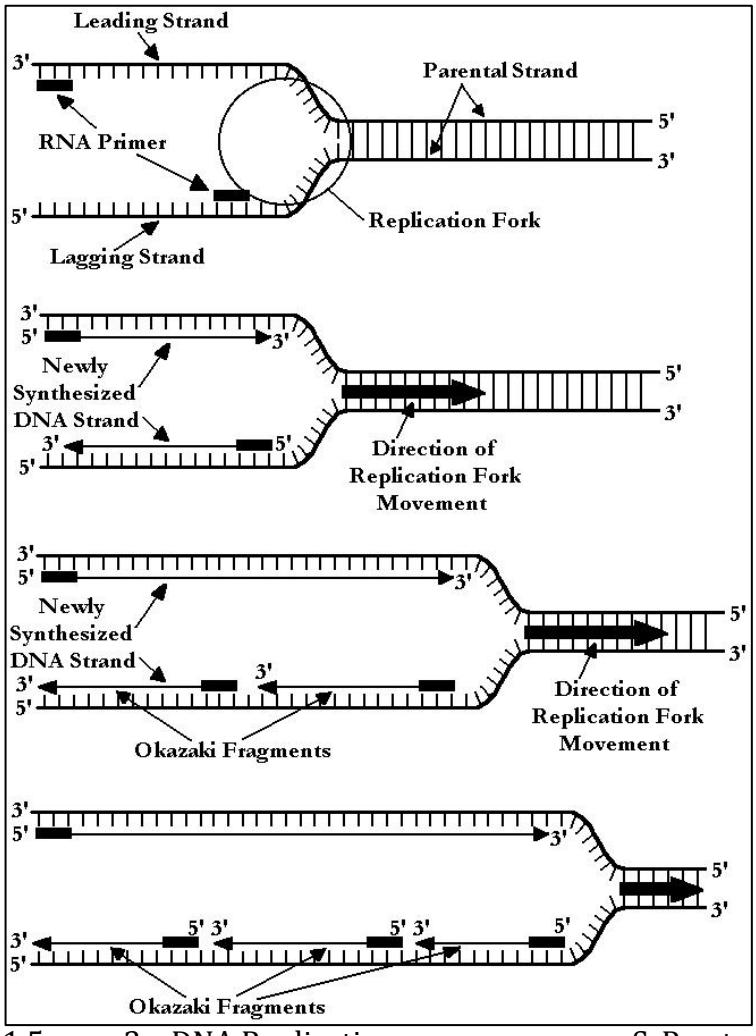
DNA replication

DNA replication can only occur in a 5' to 3' direction. As the strand of DNA is unwound and unzipped it will expose 2 strands. One of the strands will unravel and the **complimentary strand is made in the 5' to 3' direction**. This can be carried out by the cell as a continuous and uninterrupted process. However, the other strand unravels and needs a complimentary strand to be made in a 3' to 5' direction and therefore replication of this strand is in segments that are added to the strand in the 5' to 3' direction. The leading strand is always synthesized going towards the replication fork and the lagging strand away from the replication fork.



Notice that complimentary DNA nucleotides are added to the leading strand nucleotide by nucleotide as the strand unwinds in a continuous and smooth process.

On the lagging strand complimentary groups of nucleotides known as Okazaki fragments are added to the 5' end as the strand unwinds.



On the **leading strand**:

1. A short RNA primer is added by RNA primase.
2. DNA polymerase adds nucleotides going towards the replication fork.

On the **lagging strand**:

1 A short RNA primer is added by RNA primase.

2 DNA polymerase adds fragments going away from the replication fork.

3 This produces short fragments of DNA (okazaki fragments)

4 The fragments are joined together by an enzyme called DNA ligase.

In both strands at the end of replication the RNA primers are removed and replaced with DNA nucleotides this is carried out by the enzyme DNA polymerase.

Extension Material (just for interest)

Fidelity of DNA Replication

The error rate during DNA replication is less than 1 in 10^9, much better than what one might predict based on the thermodynamics (chance of weak hydrogen bonding between mismatched bases allowing a misincorporation), which is about 1 in 10^4.

Why?

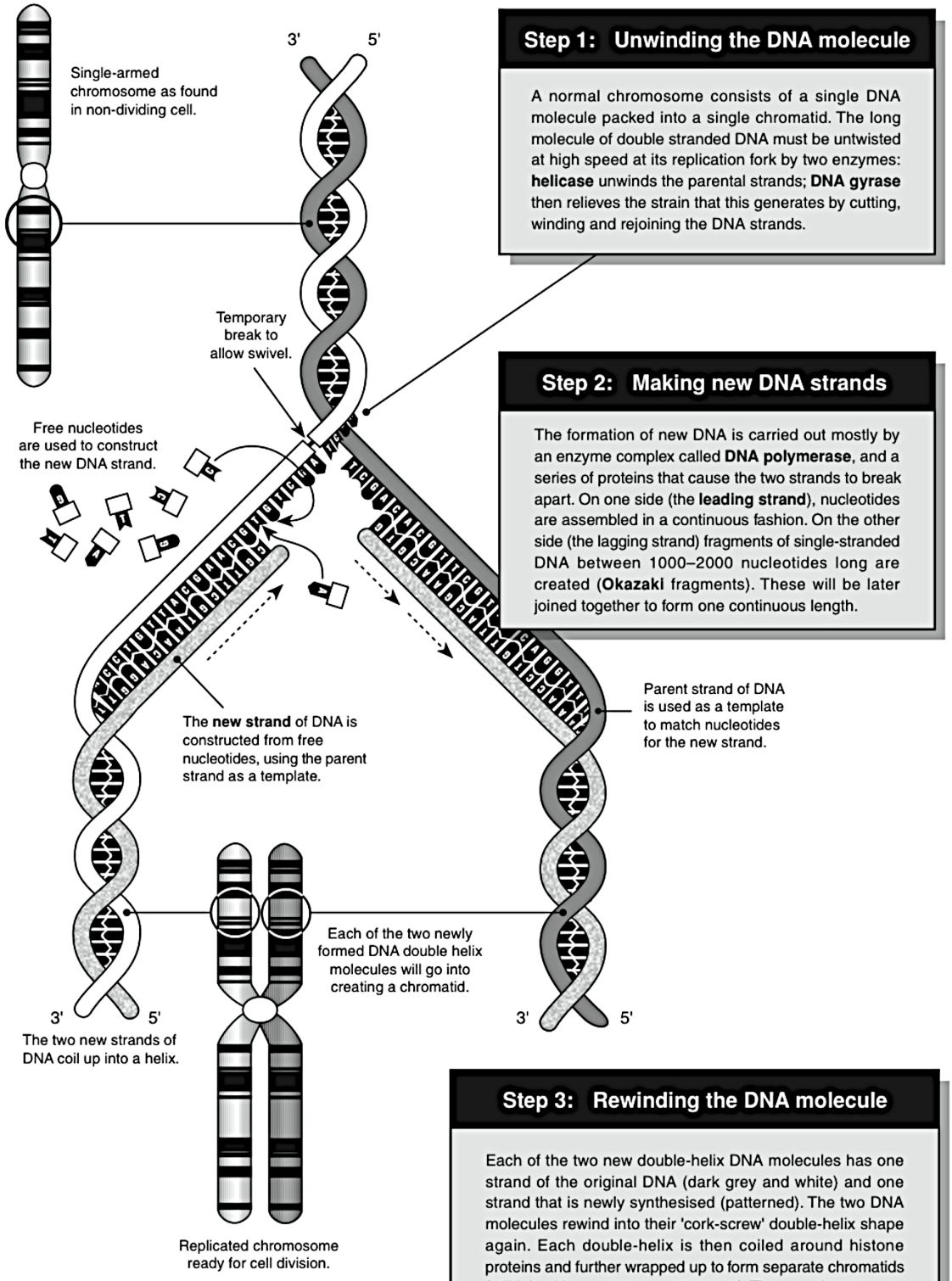
- DNA polymerase has the ability to discriminate between the correct and incorrect base.
- Other enzymes DNA pol I, III, d and e have proofreading activity which allows them to detect and remove misincorporated bases.
- DNA repair by other distinct enzymes can occur after DNA replication has taken place.

A circular prokaryotic genome has a single origin of replication from which two replication forks will form and move directionally. The replication complexes will stop and fall off the DNA when they meet in the middle of the molecule.

Eukaryotic chromosomal DNA has multiple origins of replication form which bidirectional replication forks also form. Proteins that bind to eukaryotic origins of replication act as licensing factors ensure that replication occurs at each origin during a single round of DNA replication. This maintains the fidelity of the genome.

DNA Replication

The replication of DNA is a necessary preliminary step for cell division (both mitosis and meiosis). This process creates the **two chromatids** that are found in chromosomes that are preparing to divide. By this process, the whole chromosome is essentially duplicated, but is still held together by a common centromere. Enzymes are responsible for all of the key events. The diagram below shows the essential steps in the process. The diagram on the next page shows how enzymes are involved at each stage.



Step 1: Unwinding the DNA molecule

A normal chromosome consists of a single DNA molecule packed into a single chromatid. The long molecule of double stranded DNA must be untwisted at high speed at its replication fork by two enzymes: **helicase** unwinds the parental strands; **DNA gyrase** then relieves the strain that this generates by cutting, winding and rejoining the DNA strands.

Step 2: Making new DNA strands

The formation of new DNA is carried out mostly by an enzyme complex called **DNA polymerase**, and a series of proteins that cause the two strands to break apart. On one side (the **leading strand**), nucleotides are assembled in a continuous fashion. On the other side (the lagging strand) fragments of single-stranded DNA between 1000–2000 nucleotides long are created (**Okazaki** fragments). These will be later joined together to form one continuous length.

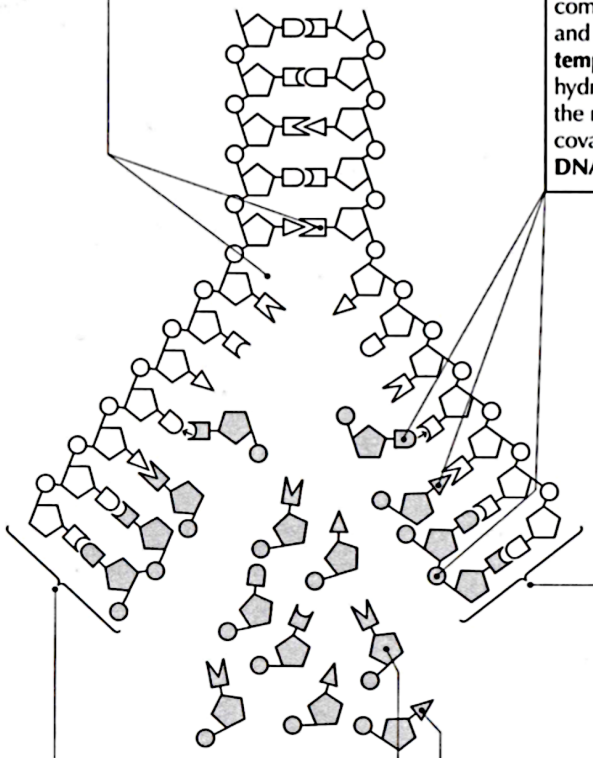
Step 3: Rewinding the DNA molecule

Each of the two new double-helix DNA molecules has one strand of the original DNA (dark grey and white) and one strand that is newly synthesised (patterned). The two DNA molecules rewind into their 'cork-screw' double-helix shape again. Each double-helix is then coiled around histone proteins and further wrapped up to form separate chromatids (still joined by a common centromere). The new chromosome has actually twice as much DNA as a regular (non-replicated) chromosome. The two chromatids will become separated in the cell division process to form two separate chromosomes.

DNA replication and chromosomes

The double helix is unwound and the base-pairs are separated by the enzyme **DNA helicase.**

Nucleotides are located opposite their complementary base (A–T and G–C) on the **DNA template strand,** the hydrogen bonds form and the nucleotides are linked covalently by the enzyme **DNA polymerase.**



The two daughter DNA strands are synthesised in slightly different ways – one is made as a continuous strand, the other as a series of short strands joined together by the enzyme **DNA ligase.**

Each replica DNA double helix is a hybrid of **one parent** and **one daughter** strand: this is called **semi-conservative replication** because half of the original (parent) DNA has been conserved in each new DNA molecule.

Supply of free nucleotides for assembly into new DNA molecule alongside unwinding template.

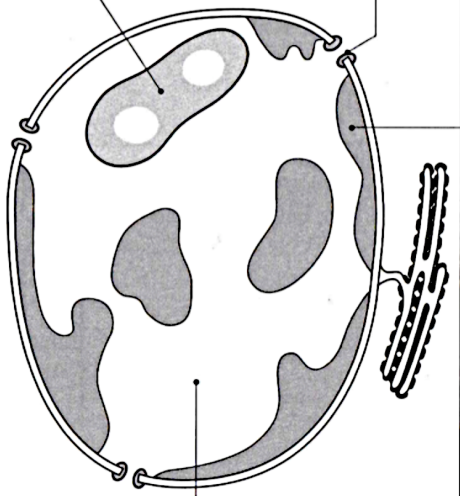
In prokaryotes, e.g. bacteria:
- the DNA is not enclosed in a nucleus;
- the DNA is 'naked' – it has no protein scaffold;
- the DNA forms circles – some (the plasmids) can be very small.

Nucleolus is the site of manufacture of ribosomal subunits. Within the nucleolus are **nucleolar organisers** which contain multiple copies of the genes which are transcribed to ribosomal RNA.

The nucleolus breaks down in preparation for nuclear division, and is reassembled at the end of telophase.

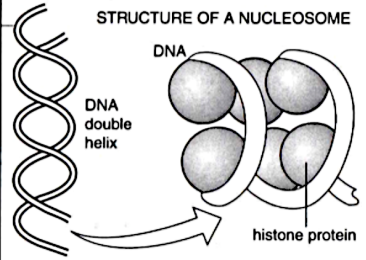
Nuclear envelope is a double membrane.

Nuclear Pore can regulate the entry (e.g. ribosomal proteins, nucleotides) and exit (e.g., ribosomal subunits, messenger RNA) of molecules to and from the nucleus. There is a highly organised arrangement of proteins around the nuclear pore to carry out this controlled transport.



Nucleoplasm, the cytoplasm of the nucleus, contains a variety of solutes, including ATP (energy source) and other nucleoside triphosphates which are the raw materials for DNA replication. The enzyme complex which regulates the replication of DNA **(DNA polymerase)** is also found here, as are ribosomal proteins awaiting assembly with ribosomal RNA into ribosomal subunits.

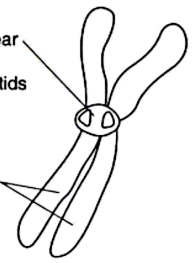
Chromatin is the genetic material containing the coded information for protein synthesis in the cell. It is made up of DNA bound to basic proteins called **histones.** The protein acts like a scaffold (support) for the DNA.



During nuclear division the chromatin condenses to form the **chromosomes**, and the chromatin containing DNA which is being 'expressed' (transcribed into mRNA) becomes visible as more loosely coiled threads.

Centromere and kinetochores attach chromosome to nuclear spindle and control separation of chromatids at anaphase.

Sister chromatids



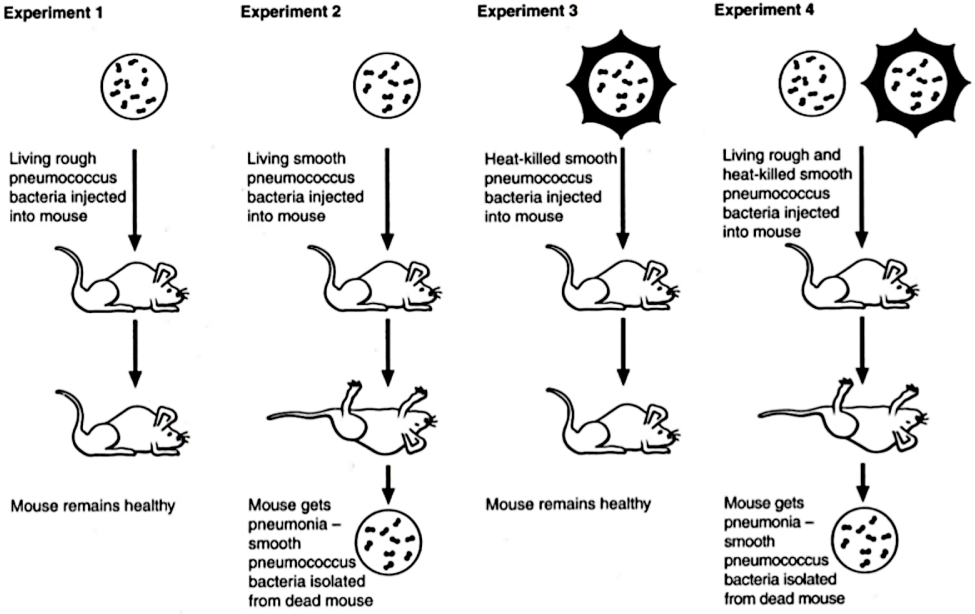
As division gets underway the DNA replicates – each chromosome becomes two identical chromatids (and each chromatid has DNA on its protein support).

Experiments on DNA function

Griffith's experiment: DNA is the genetic material

Griffith used two strains of **Pneumococcus:**

BOTH STRAINS CAN BE KILLED BY HEAT TREATMENT.



Interpretation	Interpretation	Interpretation	Interpretation
Rough pneumococcus bacteria are not infective.	Smooth pneumococcus bacteria are infective.	Smooth pneumococcus bacteria that are killed by heat are not infective.	Non-infective rough bacteria have been transformed into smooth bacteria as a result of being mixed with heat-killed smooth bacteria.

The **transforming principle** discovered by Griffith:

- is **not** affected by **protease;**
- **is** destroyed by **DNAase;**

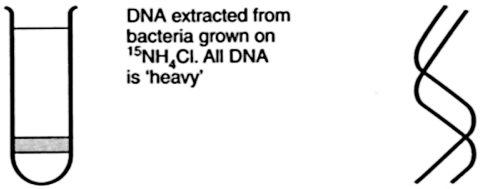
i.e. **the transforming principle is DNA.**

Genetic engineering shows that transfer of DNA alters characteristics of organisms.

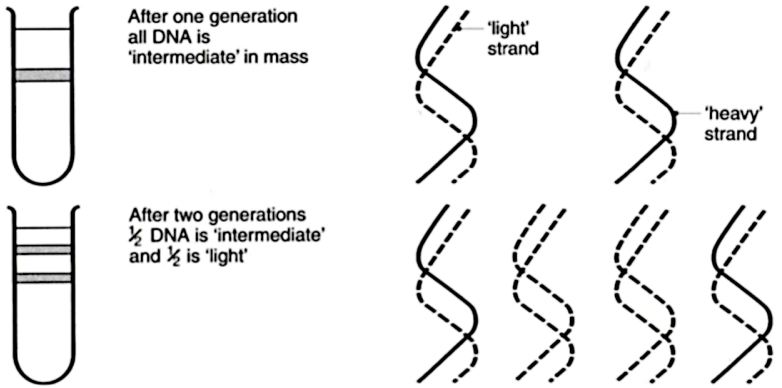
This is the most compelling evidence that DNA is the genetic material.

Meselsohn and Stahl demonstrate that DNA replication is semi-conservative

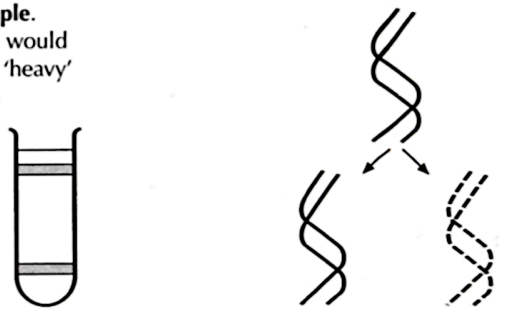
- Used *Escherichia coli*, a harmless gut bacterium.
- Grew colonies of *E. coli* with NH_4Cl as the nitrogen source for DNA synthesis.
- Were able to use **density gradient centrifugation** to identify DNA.
- A 'heavy' (not radioactive) isotope of nitrogen, ^{15}N, is available.



Bacteria grown on $^{15}NH_4Cl$ for many generations are transferred to $^{14}NH_4Cl$ for several generations.



- The presence of 'intermediate' DNA after growth in $^{14}NH_4Cl$ supports the **semi-conservative principle**.
- **Conservative replication** would produce two bands, one 'heavy' and one 'light', after one generation in $^{14}NH_4Cl$.



Bio Factsheet

Number 22

Protein synthesis I - Nucleic Acids

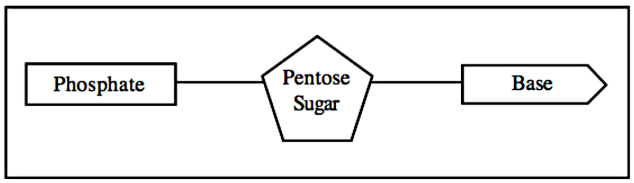
Proteins are large, organic molecules which play a fundamental role in metabolic activities including nutrition, respiration, transport, sensitivity, co-ordination and reproduction.

The characteristics of cells and organisms are determined by the particular proteins which are present. The synthesis of these proteins involves two types of nucleic acid; DNA and RNA. **DNA** is contained within the nucleus of a cell and carries the code to determine which particular proteins are made. Various forms of **RNA** then carry this information to the cytoplasm of the cell and assemble the protein. To understand protein synthesis, you must first have an understanding of DNA and RNA.

Nucleic acids

DNA and RNA are both nucleic acids. Nucleic acids are macromolecules (large molecules) made up of chains of individual units called **nucleotides**. Each nucleotide is made up of 3 parts (Fig 1):

Fig 1. Diagrammatic representation of a nucleotide



1. A **phosphate group** (H_3PO_4), which is the same in all nucleotides.

2. A **pentose (5 carbon atoms) sugar**. This sugar can either be **ribose** sugar ($C_5H_{10}O_5$) or **deoxyribose** sugar ($C_5H_{10}O_4$)

3. One of five **nitrogenous bases**. These bases are divided into two types, depending on their structure (Fig 2):
   (a) **Purines** - Bases made up of one six-sided ring and one five-sided ring.
   (b) **Pyrimidines** - Bases made up of a single six-sided ring. The details of these rings is given in Table 1.

Fig 2. The ring structure of pyrimidines and purines

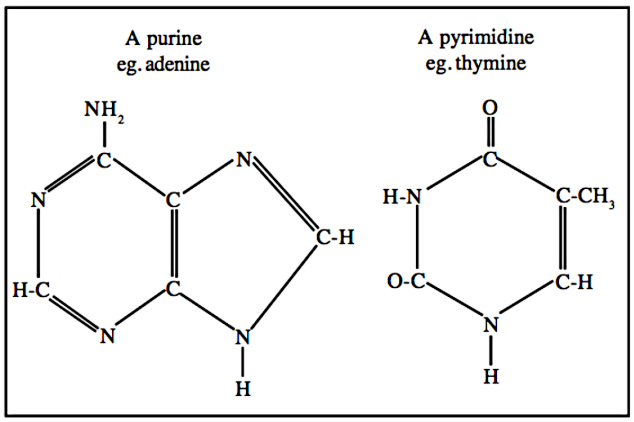
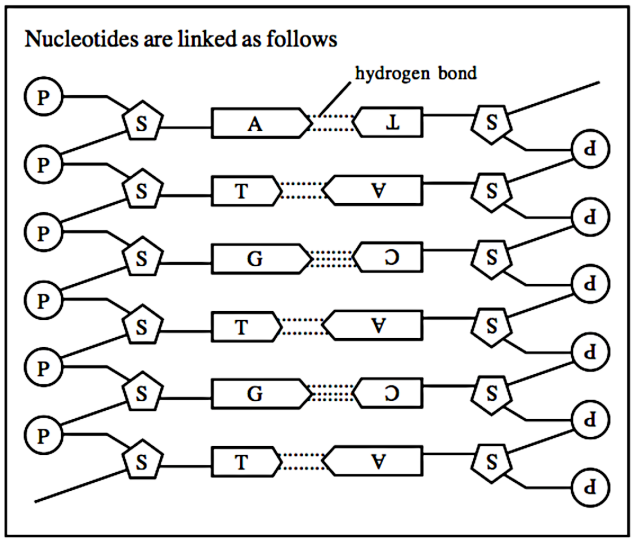


Table 1. Nitrogenous bases in nucleic acids

Ring structure	Base	Symbol	Nucleic acid
Purine (double)	Adenine Guanine	A G	DNA/RNA DNA/RNA
Pyrimidine (single)	Cytosine Thymine Uracil	C T U	DNA/RNA DNA RNA

The three components of nucleotides are joined together by **condensation** reactions (through the removal of water). Individual nucleotides are then joined together by similar condensation reactions between the phosphate group of one nucleotide and the pentose sugar of another (Fig 3). This linkage of nucleotides forms long chains, called **polynucleotides**, which make up nucleic acids.

Fig 3. Formation of a polynucleotide



From Fig 3, it can be seen that polynucleotides have a 'backbone' of phosphate and sugar, with the nitrogenous bases projecting inwards.

Exam hint *- Not all Examination Boards require candidates to be able to recognise purines and pyrimidines but all expect candidates to know that purines are larger molecules than pyrimidines and that A and G are purines etc.*

Comparing DNA & RNA
DNA and RNA are both vital in protein synthesis. Table 2 summarises the similarities and differences between these two macromolecules:

Table 2. Comparison of DNA and RNA

DNA	RNA
Formed in nucleus	Formed in nucleus
Predominantly found in nucleus	Found throughout the cell
Double strand of nucleotides - coiled into a double helix. The two strands are linked by hydrogen bonding between the bases (Fig 3): Cytosine with Guanine, Adenine with Thymine	Single strand of nucleotides which can be folded into different shapes
Pentose sugar present - Deoxyribose	Pentose sugar present - Ribose
Bases present: Cytosine, Guanine, Adenine, Thymine	Bases present: Cytosine, Guanine, Adenine, Uracil
Larger molecule	Smaller molecule
One basic form	Three main forms: messenger RNA, transfer RNA, ribosomal RNA
Ratio of 1:1 for adenine:thymine, and cytosine:guanine	Ratio of adenine:thymine, and cytosine:guanine variable

***Exam hint** - Do **not** confuse thymine with thiamine.*

To summarise, DNA and RNA are both made up of nucleotides. In DNA, there are two nucleotide strands which are wound around each other at approximately every ten bases. Thus DNA forms a helix. The strands are **anti-parallel** - i.e. they run in opposite directions to each other. The two strands of nucleotides which make up the DNA double helix are held together by the **hydrogen bonding** between nitrogenous bases. This paring is always as follows:

- **Adenine with Thymine (A-T)**
- **Cytosine with Guanine (C-G)**

The different structures of the bases result in two hydrogen bonds being formed A to T (A=T), and three hydrogen bonds between C to G (C≡G).

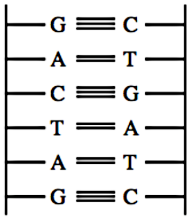
The bonding of the nitrogenous bases ensures that purines always bond with pyrimidines, and more specifically, A to T and C to G. The precise nature of this bonding is biologically important for two reasons:

1. The structure of DNA remains exact and regular. This is vital since DNA carries the heredity material for an individual.
2. DNA can exist as a very long sequence of bases, with an enormous variety in order, to carry the large amount of genetic information for an individual.

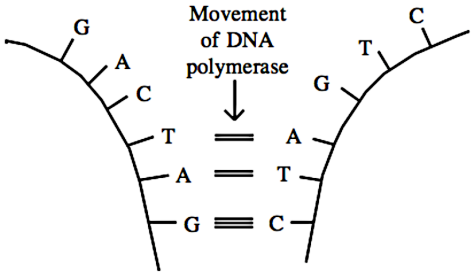
DNA Replication
The replication of DNA takes place shortly before cell division, during a phase of the cell cycle called **interphase**. DNA replication is said to be **semi-conservative**. This means that when two new double helixes of DNA are produced, one of the strands of each helix is from the original (parental) DNA strand and the other is new. The sequence of diagrams in Fig 4 illustrate the replication of DNA.

Fig 4. Replication of DNA

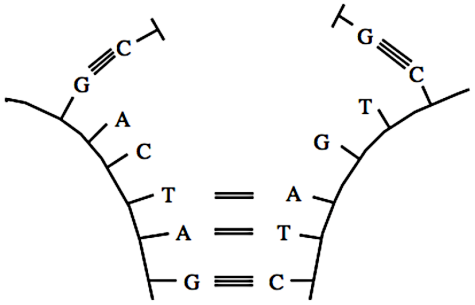
1. A portion of the DNA double helix about to be replicated



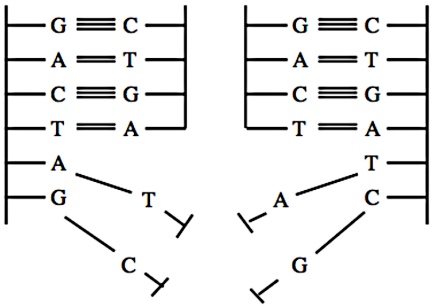
2. Replication has started. The enzyme **DNA polymerase** moves along the DNA double helix unwinding it and 'unzipping it' by breaking the hydrogen bonds between the nitrogenous bases.



3. **Free nucleotides** in the nucleoplasm of the nucleus are attracted to the exposed complementary bases and form new hydrogen bonds with them.



4. DNA polymerase continues to move along the DNA, exposing the bases for free nucleotides to come into and bond. Once these new nucleotides are in place they bond together (phosphate to deoxyribose sugar) forming a new strand of DNA.



5. Replication is now complete, forming two identical strands of DNA which are exact copies of the original strand. This method is said to be semi-conservative, since each strand retains **half** of the original DNA material.

Evidence for semi-conservative DNA replication

The evidence for semi-conservative DNA replication came from experiments by **Matthew Meselsohn** and **Franklin Stahl**, two scientists at the California Institute of Technology, using the bacterium *Escherichia coli*. Matthew and Franklin experiments can be explained in the following series of steps:

1. *E. coli* were cultured in a growth medium containing nitrogen in the form of the isotope ^{15}N (known as 'heavy nitrogen').
2. By leaving the E. coli in the culture for a long enough period of time, all DNA in the *E. coli* became made up of 'heavy nitrogen'. This meant that the molecular weight of the DNA in these *E. coli* was measurably greater.
3. The *E. coli* containing the 'heavy nitrogen' were then placed into a medium containing normal nitrogen (^{14}N), so that any new DNA manufactured would be from this normal nitrogen.
4. The *E. coli* was allowed to divide once and the first generation cells were then collected.
5. When the DNA was extracted from these cells and the relative weight determined using a centrifugation technique, the molecular weight of the DNA was found to be **intermediate** between heavy and light types. This confirmed that the DNA was made up of one original (heavy) strand of DNA and one new (light) strand of DNA - Semi-conservative replication.

Practice Questions

1. Define the following terms:
   (a) DNA double helix (3 marks)
   (b) complementary base pairing (3 marks)
   (c) semi-conservative replication of DNA (2 marks)

2. (a) Read through the following account of DNA replication, then find the most appropriate word or words to complete the account.

During DNA replication, the enzyme ..... binds to the DNA double .....This causes the DNA to ..... and breaks the ..... bonds between the nucleotides. These nucleotides are bound together at ..... bases. The base adenine binds with ..... and ..... binds with guanine. Free nucleotides found in the ..... bind with the exposed bases producing two strands of DNA. The process is said to be ..... because in both of the two DNA strands produced, one sequence of nucleotides is new and the other is from the .....DNA. (10 marks)

(b) When a sample of DNA is extracted from the nucleus of a cell, chemical analysis showed that 38% of the bases were adenine. What percentage of the bases are guanine (3 marks)

3. DNA and RNA are major molecules involved in the transfer of hereditary material and protein synthesis.
   (a) To which group of molecules do DNA and RNA belong? (1 mark)
   (b) DNA and RNA are both composed of nucleotide sub-units. Describe the structure of a nucleotide. (3 marks)
   (c) State four similarities and four differences between a DNA molecule and an RNA molecule (8 marks)

Answers

Marking points are shown by semicolons

1. (a) Two strands of nucleotide;
   held together by hydrogen bonding;
   coiled or twisted around each other (approximately every 10 bases).

   (b) hydrogen bonding between pairs of organic bases;
   (projecting from the sugar-phosphate backbone of nucleic acids);
   pairing occurs between adenine-thymine, guanine-cytosine in DNA;
   pairing between adenine-uracil, guanine-cytosine in RNA.
   (Any 3)

   (c) Half of the original parent molecule is retained/conserved;
   half is composed of new nucleotide molecules.

2. (a) DNA polymerase;
   helix;
   unwind;
   hydrogen;
   nitrogenous/exposed;
   thymine;
   cytosine;
   nucleoplasm/nucleus;
   semi-conservative;
   parental/original.

   (b) 38% adenine, ∴ 38% thymine;
   remaining 24% is cytosine and guanine (50% each);
   ∴ 12% guanine.

3. (a) nucleic acids.

   (b) phosphate;
   ribose/5C sugar;
   nitrogenous base;
   components joined by condensations reactions

   (c) (see Table 2)

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Practice Questions

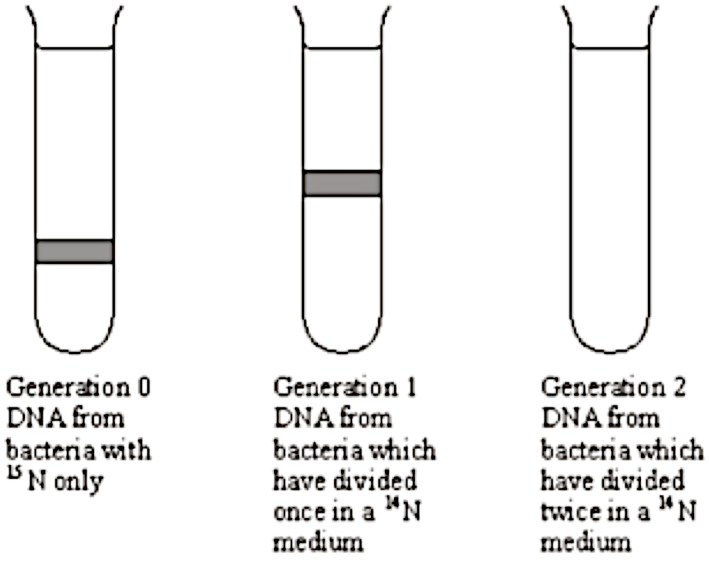
1.

(a) There are two forms of nitrogen. These different forms are called isotopes. ^{15}N is a heavier isotope than the normal isotope ^{14}N.

In an investigation, a culture of bacteria was obtained in which all the nitrogen in the DNA was of the ^{15}N form. The bacteria (generation 0) were transferred to a medium containing only the normal isotope, ^{14}N, and allowed to divide once. A sample of these bacteria (generation 1) was then removed. The DNA in the bacteria of generation 1 was extracted and spun in a high-speed centrifuge.

The bacteria in the ^{14}N medium were allowed to divide one more time. The DNA was also extracted from these bacteria (generation 2) and spun in a high speed centrifuge.

The diagram shows the results of this investigation.



(i) Which part of the DNA molecule contains nitrogen?

.....

(1)

(ii) Explain why the DNA from generation 1 is found in the position shown.

.....

.....

.....

.....

(2)

(iii) Complete the diagram to show the results for generation 2.

(2)

(b) The table shows the percentage of different bases in the DNA of different organisms.

Organism	Adenine%	Guanine%	Thymine%	Cytosine%
Human		19		
Bacterium	24	26	24	26
Virus	25	24	33	18

(i) Complete the table to show the percentages of different bases in human DNA.

(2)

(ii) The structure of virus DNA is different from the DNA of the other two organisms. Giving evidence from the table, suggest what this difference might be.

.....

.....

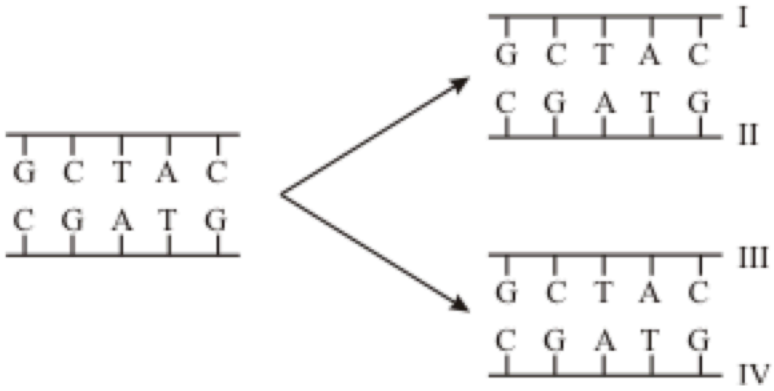
.....

.....

(2)
(Total 9 marks)

2.

The diagram below shows a short section of DNA molecule before and after replication. If the nucleotides used to replicate the DNA were radioactive, which strands in the replicated molecules would be radioactive?



A. II and III only

B. I and III only

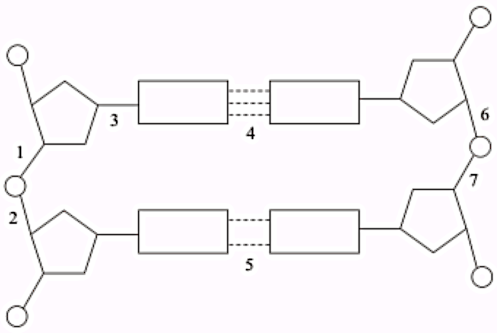
C. I and II only

D. I, II, III and IV

(Total 1 mark)

3.

During the process of replication, which bond(s) in the diagram of DNA below is/are broken?



A. 3

B. 4, 5

C. 1, 2, 6, 7

D. 1, 7, 4, 5

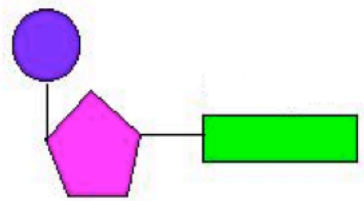
(Total 1 mark)

Essay Question:

Living organisms use DNA as their genetic material. Explain how DNA is replicated within the cells of living organisms.

(Total 8 marks)

DNA Nucleotide Structure



Label the nucleotide with: NITROGENOUS BASE, PHOSPHATE GROUP & DEOXYRIBOSE SUGAR

Nucleotide Bases

The four nucleotide bases found in a DNA molecule are:-

- _____ (Pyrimadine)
- _____ (Pyrimadine)
- _____ (Purine)
- _____ (Purine)

The complimentary base pairs are:

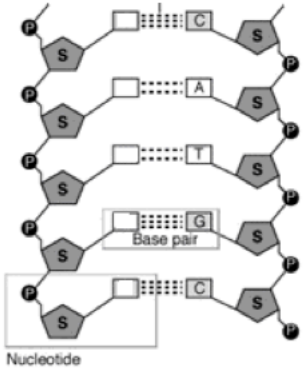
_____ with _____ AND _____ with _____

Pyramadines and Purines are complimentary because _____.

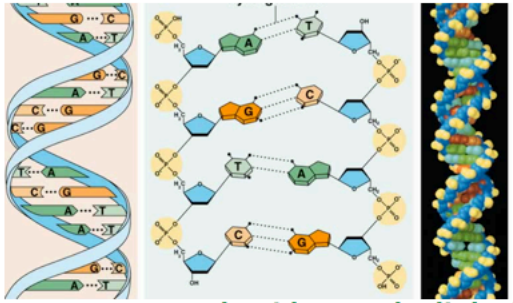
BONDING

Hydrogen or covalent?

Complete the labels



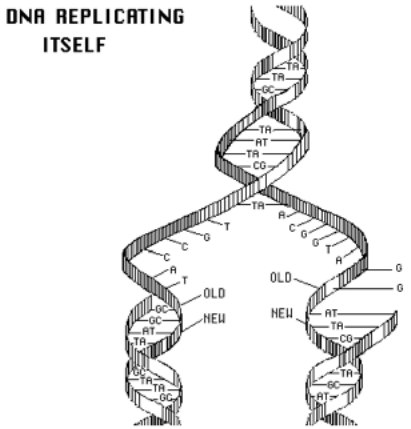
Double Helix – Molecular Structure



_____ bonds link the two strands together between the _____. A with _____ and C with _____ This is called _____ _____ _____.

Two DNA nucleotides can be linked together by a _____ bond between the _____ of one nucleotide and the _____ group of another to form a single _____. DNA molecules consist of _____ strands wound together to form a _____ _____.

DNA Replication



DNA replication is a way of _____ DNA. Each molecule formed consists of one neqw strand and one old strand conserved from the parent DNA molecule i.e. it is _____ conservative.

- DNA _____ unwinds and separates the strands.
- DNA _____ links new free nucleotides to the single strand template by _____ bonds.
- The two new _____ molecules each _____ into a helix. They are are _____ to the other template.